REMARKS

Claims 1-10, 12-19, 21 and 22 are pending. By this amendment, claims 23 and 24 are canceled without prejudice to, or disclaimer of, the subject matter contained therein.

Entry of the amendments is proper under 37 C.F.R. §1.116 since the amendments: (a) place the application in condition for allowance for the reasons discussed herein; (b) do not raise any new issue requiring further search and/or consideration because the amendments merely cancel some rejected claims; and (c) place the application in better form for appeal, should an appeal be necessary. The amendments are necessary and were not earlier presented because they are made in response to arguments raised in the final rejection. Entry of the amendments is thus respectfully requested.

I. REPLY TO REJECTIONS

On page 2, item 3 of the Office Action, claims 1, 3-10, 12, 14-19 and 21-24 are rejected under 35 U.S.C. §102(e) over U.S. Patent No. 6,316,822 to Venkateshwaran et al. (hereinafter "Venkateshwaran"). The cancellation of claims 23 and 24 renders the rejection of these claims moot. The rejection of the remaining claims is respectfully traversed.

Applicant respectfully submits that Venkateshwaran is not statutory prior art as its U.S. filing date of September 15, 1999, is subsequent to the filing date of October 30, 1998, of JP 10-326184, from which this application claims priority. Filed herewith is a verified English translation of JP 10-326184 for the Examiner's benefit so that the Examiner may confirm that the subject matter of this application was invented prior to the U.S. filing date of Venkateshwaran.

Because of the above, Applicant respectfully submits that claims 1-10, 12-19, 21 and 22 are patentable over the applied reference. Withdrawal of the rejection of the claims is respectfully submitted.

On page 5, item 5 of the Office Action, claims 2 and 13 are rejected under 35 U.S.C. §103(a) over Venkateshwaran in view of JP-07-169795 to Oda. The rejection is respectfully traversed.

As discussed above, Venkateshwaran is not statutory prior art. As Oda fails to suggest the features of claims 1 and 12, from which claims 2 and 13 respectively depend from, the claims are patentable over the applied references. Withdrawal of the rejection is respectfully requested.

II. CONCLUSION

For the reasons stated above, Applicant submits that this application is in condition for allowance. Favorable reconsideration and prompt allowance are respectfully requested.

Should the Examiner believe that anything further would be desirable in order to place this application in better condition for allowance, the Examiner is invited to contact Applicant's undersigned representative at the telephone number listed below.

Respectfully submitted,

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Attachment:
Verified English Translation of JP 10-326184.

Date: May 28, 2004

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DECLARATION

I, Tatsuya Ina, a Patent Attorney, of Ogikubo TM Bldg. 2F, 5-26-13, Ogikubo, Suginami-ku, Tokyo 167-0051, Japan, solemnly and sincerely declare:

That I have a thorough knowledge of Japanese and English languages; and

That the attached pages contain a correct translation into English of the specification of the following Japanese Patent Application:

APPLICATION NUMBER	DATE OF APPLICATION
10-326184	October 30, 1998

Signed this 26th day of May, 2004.

Tatsuya Ina

[Title of the Document] Patent Application

[Agent's File Reference] EP154801

[Filing Date] October 30, 1998

[Attention] Director-General, The Patent Office

[IPC] H01L 21/60

[Title of the Invention] Semiconductor device and method of manufacture thereof, circuit board, and electronic instrument

[Number of Claims] 12

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[List of the Documents Attached]

[Document] Specification	1 copy
[Document] Drawings	1 copy
[Document] Abstract	1 copy
[Number of General Power of Attorney]	9402500

[Title of Document] SPECIFICATION

[Title of the Invention] SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURE THEREOF, CIRCUIT BOARD, AND ELECTRONIC INSTRUMENT

[Claims]

[Claim 1] A method of manufacture of a semiconductor device, comprising the steps of:

providing an adhesive between a surface of a semiconductor element having a plurality of electrodes on which said electrodes are provided and a surface of a substrate having a plurality of leads formed on which said leads are formed;

positioning at least one of said plurality of electrodes to oppose at least one of said plurality of leads; and

applying pressure in a direction such as to make a gap between said semiconductor element and said substrate narrower;

wherein on the surface of said substrate in a region opposing the surface of said semiconductor element except a region for said leads, a film is formed with a lower adhesion to said adhesive than said substrate.

[Claim 2] The method of manufacture of a semiconductor device as defined in claim 1,

wherein said adhesive is formed of an anisotropic conductive material having conductive particles dispersed in an insulating material.

[Claim 3] The method of manufacture of a semiconductor device as defined in claim 1 or 2,

wherein said leads and said film are formed by etching a conductive foil adhered to said substrate.

[Claim 4] The method of manufacture of a semiconductor device as defined in any one of claims 1 to 3,

wherein said electrodes are provided on an extremity of said surface of said semiconductor element; and

wherein said film is formed in a region opposing a central part of said surface of said semiconductor element.

[Claim 5] The method of manufacture of a semiconductor device as defined in any of claims 1 to 4,

wherein said film is formed to spread two-dimensionally, with at least one opening exposing a surface of said substrate.

[Claim 6] A semiconductor device comprising:

a semiconductor element having a plurality of electrodes;

a substrate on which is formed a plurality of leads; and

an adhesive provided between a surface of said semiconductor element on which said electrodes are formed and a surface of said substrate on which said leads are formed, and adhering said semiconductor element and said substrate,

wherein at least one of said plurality of electrodes and at least one of said plurality of leads are electrically connected; and

wherein on said substrate in a region opposing said semiconductor element except a region for said leads, a film is formed with a lower adhesion to said adhesive than said substrate.

[Claim 7] The semiconductor device as defined in claim 6,

wherein said adhesive is formed of an anisotropic conductive material having conductive particles dispersed in an insulating material.

[Claim 8] The semiconductor device as defined in claim 6 or 7,

wherein said leads and said film are formed of the same electrically conductive material.

[Claim 9] The semiconductor device as defined in any one of claims 6 to 8,

wherein said electrodes are provided at an extremity of said surface of said semiconductor element; and

wherein said film is formed in a region opposing a central part of said surface of said semiconductor element.

[Claim 10] The semiconductor device as defined in any one of claims 6 to 9,

wherein said film is formed to spread two-dimensionally, with at least one opening exposing a surface of said substrate.

[Claim 11] A circuit board on which is mounted the semiconductor device as defined in any one of claims 6 to 10.

[Claim 12] An electronic instrument having the semiconductor device as defined in any one of claims 6 to 10.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a semiconductor device and method of manufacture thereof, to a circuit board, and to an electronic instrument.

[0002]

[Background of the Invention]

The method of using an anisotropic conductive film for electrical connection between substrates is well known. Japanese Patent Application Laid-Open No. 4-317347 describes the bonding of a semiconductor element and substrate in which this method is applied to flip-chip bonding.

[0003]

An adhesive such as an anisotropic conductive film has high adhesion with the substrate, and therefore holes and voids tend to be formed in the surface of the substrate. Holes and voids act as gathering places for moisture, and thus have an adverse effect on reliability.

[0004]

The present invention solves this problem, and has as its objective the provision of a semiconductor device and method of manufacture thereof, a circuit board, and an electronic instrument, such that holes and voids rarely occur in the surface of the substrate.

[0005]

[Means for Solving the Problems]

(1) The method of manufacture of a semiconductor device of the present invention comprises the steps of:

providing an adhesive between a surface of a semiconductor element having a plurality of electrodes on which the electrodes are provided and a surface of a substrate having a plurality of leads formed on which the leads are formed;

positioning at least one of the plurality of electrodes to oppose at least one of the plurality of leads; and

applying pressure in a direction such as to make the gap between the semiconductor element and the substrate narrower;

wherein on the surface of said substrate in a region opposing the surface of said semiconductor element except a region for said leads, a film is formed with a lower adhesion to said adhesive than said substrate.

[0006]

According to the present invention, since the semiconductor element and substrate are adhered by the adhesive, bonding of the two is achieved simply, and moreover the electrical connection of the electrodes and leads can be ensured. On the substrate, in a region opposing the surface of the semiconductor element, a film is formed which has a lower adhesion with the adhesive than the substrate. Therefore, holes and voids rarely occur in this film surface, whereby a semiconductor device of high reliability can be manufactured.

[0007]

(2) In this method of manufacture of a semiconductor device, the adhesive may be formed of an anisotropic conductive material having conductive particles dispersed in an insulating material.

[0008]

By means of this, the electrodes and leads can be electrically connected by the conductive particles, and the electrical connection can be carried out simultaneously with the adhesion of the semiconductor element and the substrate.

[0009]

(3) In this method of manufacture of a semiconductor device, the leads and the film may be formed by etching a conductive foil adhered to the substrate.

[0010]

By doing this, the leads and film can be formed simply in a small number of steps.

[0011]

(4) In this method of manufacture of a semiconductor device, the electrodes may be provided on an extremity of the surface of the semiconductor element, and the film may be formed in a region opposing a central part of the surface of the semiconductor element.

[0012]

By means of this, since the film with a low adhesion with the adhesive is formed in the central part in which holes and voids tend to form, a large benefit is obtained.

[0013]

(5) In this method of manufacture of a semiconductor device, the film may be formed to spread two-dimensionally, with at least one opening exposing a surface of the substrate.

[0014]

By doing this, since the surface of the substrate is exposed in the opening, in this portion the adhesion of the adhesive is increased, and the adhesive force between the semiconductor element and the substrate is increased.

[0015]

(6) A semiconductor device of the present invention comprises:

a semiconductor element having a plurality of electrodes;

a substrate on which is formed a plurality of leads; and

an adhesive provided between a surface of the semiconductor element on which the electrodes are formed and a surface of the substrate on which the leads are formed, and adhering the semiconductor element and the substrate,

wherein at least one of the plurality of electrodes and at least one of the plurality of leads are electrically connected; and

wherein on said substrate in a region opposing said semiconductor element

except a region for said leads, a film is formed with a lower adhesion to said adhesive than said substrate.

[0016]

According to the present invention, the semiconductor element and substrate are adhered by the adhesive, and the electrical connection between the electrodes and leads is achieved. On the substrate, in a region including at least a part of the region opposing the semiconductor element, a film is formed, having a lower adhesion with the adhesive than the substrate. Therefore, on this film surface, holes and voids become more easily dispersed, and are reduced in size to a tolerable level, whereby the reliability is increased.

[0017]

(7) In this semiconductor device, the adhesive may be formed of an anisotropic conductive material having conductive particles dispersed in an insulating material.

[0018]

By means of this, the electrodes and leads can be electrically connected by the conductive particles, and the electrical connection can be achieved with the adhesion of the semiconductor element and the substrate.

[0019]

(8) In this semiconductor device, the leads and the film may be formed of the same electrically conductive material.

[0020]

By doing this, the leads and film can be formed simply in a small number of steps.

[0021]

(9) In this semiconductor device, the electrodes may be provided at an extremity of the surface of the semiconductor element, and the film may be formed in a region opposing a central part of the surface of the semiconductor element.

[0022]

By means of this, since the film with a low adhesion with the adhesive is formed in the central part in which holes and voids tend to form, a large benefit is obtained.

[0023]

(10) In this semiconductor device, the film may be formed to spread two-dimensionally, with at least one opening exposing a surface of the substrate.

[0024]

By doing this, since the surface of the substrate is exposed in the opening, in this portion the adhesion of the adhesive is increased, and the adhesive force between the semiconductor element and the substrate is increased.

[0025]

(11) On a circuit board of the present invention, the above semiconductor device is mounted.

[0026]

(12) An electronic instrument of the present invention has the above semiconductor device.

[0027]

[Embodiments of the Invention]

The present invention is now described in terms of a number of preferred embodiments with reference to the drawings.

[0028]

First Embodiment

Fig. 1 shows a first embodiment of the semiconductor device to which the present invention is applied, and Fig. 2 shows the substrate used in the semiconductor device shown in Fig. 1. This embodiment of the semiconductor device includes a substrate 10, a semiconductor element 20, and an adhesive 30.

[0029]

In Figs. 1 and 2, a part of the substrate 10 is shown cut away, and the overall shape thereof is not particularly restricted, and may be rectangular, polygonal, or a combination of a number of rectangles. The thickness of the substrate 10 is commonly determined by the material thereof, but this is also not restricted. The substrate 10 may be an organic or inorganic material, or may equally be a composite of the two. As the substrate 10 formed of an organic material may be cited, for example, a flexible substrate formed of a polyimide resin. As the substrate 10 formed of an inorganic material may be cited, for example, a ceramic substrate or glass substrate. As a composite construction of organic and inorganic materials may be cited, for example, a glass epoxy substrate.

[0030]

On the substrate 10 is formed an interconnect pattern including a plurality of leads 12. On a part of the leads 12 (for example, an end part), if necessary, may be formed lands being wider than the leads 12, for the purpose of bonding the semiconductor element 20 with electrodes 22. The spacing between adjacent leads 12 is preferably at least 30 μm. It should be noted that in Fig. 2, only the leads 12 are shown, but these leads 12 may be further extended and be connected to electronic components.

[0031]

The leads 12 are formed on one surface of the substrate 10, so as to avoid a part (for example, a central part). In this case, the leads 12 may be formed at the extremity of the substrate 10, and leads 12 not formed in the central part. Of the plurality of leads 12, a group of leads 12 may be formed parallel facing in a single direction. The plurality of leads 12 may be arranged to be parallel aligned in respective of a plurality of directions. In this case, the plurality of leads 12 are divided into a plurality of groups of leads 12 aligned in a plurality of directions. It should be noted that the leads 12, in addition to being formed on one surface of the substrate 10, may also be formed on the other

surface.

[0032]

The leads 12 are formed of an electrically conductive material. As an electrically conductive material may be cited a metal. For example, the leads 12 can be formed by plating the surface of copper with gold or tin. Alternatively, the leads 12 may be formed of gold.

[0033]

In the present invention, a three-layer substrate may be used, in which the leads 12 are attached to the substrate 10 with an interposed adhesive. Alternatively, the leads 12 can be formed by forming an electrically conductive film of copper or the like on the substrate by sputtering or the like, and then etching this. In this case, the leads 12 are directly formed on the substrate 10, in a two-layer substrate with no interposed adhesive. Or an additive method can be applied in which the leads 12 are formed by plating. Alternatively, a built-up substrate of multilayer construction can be used, in which an interconnect pattern is laminated to include an insulating resin and the leads 12, or a multilayer substrate in which a plurality of substrates are laminated.

[0034]

On the substrate 10, the film 14 is formed. The film 14 preferably has lower adhesion with the adhesive 30 than with the surface of the substrate 10. The film 14 is formed to avoid at least one or all of the leads 12. The film 14 is formed so as not to contact at least one or all of the leads 12. Of the plurality of leads 12, not all but at least one may contact the film 14. For example, by contacting leads 14 to be connected to ground potential (GND potential) with the film 14 so as to be electrically conductive, the whole of the film 14 may be at ground potential (GND potential). In this case, since the film 14 which is larger than the leads 14 is at ground potential (GND potential), sudden variations in the potential thereof can be absorbed.

[0035]

When the leads 12 are formed to avoid a part (for example the central part) of the surface of the substrate 10, in the portion avoided by the leads 12 (for example the central part), the film 14 can be formed. The form of the film 14 may be any of a rectangle, a polygon, or a combination of a plurality of rectangles.

[0036]

The film 14 is formed in a region opposing the surface of the semiconductor element 20 on which the electrodes 22 are formed. In more detail, the film 14 in its entirety, a part thereof, or at least a part thereof, and the surface of the semiconductor element on which the electrodes 22 are formed, except a region for the electrode 22, overlap in plan view.

[0037]

The film 14 can be made of an electrically conductive material. As an electrically conductive material may be cited a metal. For example, the film 14 can be formed with gold or tin plating over the whole surface of copper. Alternatively, the film 14 can be formed of gold. The metal commonly has a lower adhesion with the adhesive 30 than the surface of the substrate 10.

[0038]

On the above-described substrate 10 the semiconductor element 20 is mounted. The semiconductor element is mostly a semiconductor chip. On the semiconductor element 20 are formed the plurality of electrodes 22. These electrodes are preferably bumps. The semiconductor element 20 has the surface on which the electrodes 22 are formed positioned opposing the surface of the substrate 10 on which the leads 12 and film 14 are formed. At least one of the electrodes 22 is positioned on a part of one of the leads 12. If a land is formed on the lead 12, the electrode 22 is positioned on the land. The region of the surface of the semiconductor element 20 on which the electrodes 22 are formed excluding the electrodes 22 opposes all, a part, or at least a part of the film 14. Of the electrodes 22, at least one not being all may be positioned on the film 14.

[0039]

The substrate 10 and semiconductor element 20 are adhered with the adhesive 30. The adhesive 30 may be an anisotropic conductive material. In that case, between the leads 12 formed on the substrate 10 and the electrodes 22 formed on the semiconductor element 20, the conductive particles intervene, and provide an electrical connection between the two. Alternatively, the leads 12 and electrodes 22 may be directly bonded, and the substrate 10 and semiconductor element 20 may be adhered with the adhesive 30. The surface of the semiconductor element 20 on which the electrodes 22 are formed opposes the film 14.

[0040]

The adhesive 30 has a lower adhesion with the film 14 than with the substrate 10. Therefore, since the adhesive 30 has a high adhesion with the region of the substrate 10 in which the leads 12 and film 14 are not formed, it forms a strong bond between the substrate 10 and the semiconductor element 20. Since the adhesive 30 adheres to the leads 12 and film 14 with a low adhesive force, for reasons such as that the flowability is increased, voids and holes tend not to form on the surface of the leads 12 and film 14. As a result, the accumulation of moisture in voids and holes can be prevented, and the reliability can be increased.

[0041]

This embodiment is constructed as described above, and the method of manufacture thereof is now described. First, on the substrate 10, the leads 12 and film 14 are formed. The leads 12 and film 14 can be formed in separate processes, but are preferable formed in the same process. For example, a conductive foil such as a metal foil can be formed on the substrate 10, and this can be etched to form the leads 12 and film 14 together.

[0042]

The adhesive 30 is provided on at least either of the surface of the

semiconductor element 20 on which the electrodes 22 are provided and the surface of the substrate 10 on which the leads 12 and film 14 are formed. The adhesive 30 may be previously provided in a form of an adhesive tape. As the adhesive 30 can be used an anisotropic conductive material or anisotropic conductive film.

[0043]

Next, the surface of the semiconductor element 20 on which the electrodes 22 are provided and the surface of the substrate 10 on which the leads 12 and film 14 are formed are opposed. Then of the plurality of electrodes 22 at least one or the totality, and of the plurality of leads 12 at least one or the totality are positioned. Furthermore, pressure is applied in the direction of making the gap between the semiconductor element 20 and the substrate 10 narrower. When as the adhesive 30 is used an anisotropic conductive material or an anisotropic conductive film, then the conductive particles are squashed between the electrodes 22 and the leads 12, and pressure is applied until there is an electrical connection therebetween.

[0044]

By means of the above process, a semiconductor device can be manufactured. According to this embodiment, since the semiconductor element 20 and substrate 10 are adhered by the adhesive 30, bonding of both can be achieved simply, and moreover the electrical connection between the electrodes 22 and the leads 12 can be achieved. On the substrate 10, in the region opposing the surface of the semiconductor element 20, the film 14 is formed with lower adhesion to the adhesive 30 than the substrate 10. As a result, on the surface of this film 14, holes and voids are less prone to occurrence, and a semiconductor device of high reliability can be manufactured.

[0045]

Second Embodiment

Fig. 3 shows a second embodiment of a semiconductor device to which the present invention is applied, and Fig. 4 shows the substrate used in the semiconductor

device shown in Fig. 3. This embodiment of the semiconductor device comprises a substrate 40, and the semiconductor element 20 and adhesive 30 described in the first embodiment. The substrate 40 has a modified form of the film 14 of the substrate 10 described in the first embodiment, and otherwise the construction is the same as that of the substrate 10, for which reason description is omitted here.

[0046]

The film 44 of the substrate 40 differs from the film 14 in having formed at least one opening 46. The opening 46 exposes the surface of the substrate 40, and in form may be circular, rectangular, polygonal, or the like. By forming the opening 46, in at least a part of the film 40 the surface of the substrate 40 is exposed, and the adhesive 30 enters the opening 46. By doing this, the region in which the adhesive 30 adheres to the substrate 40 is increased, and the adhesion force between the semiconductor element 20 and the substrate 40 is increased. In particular, rather than forming a single large opening 46, it is preferable to form a plurality of relatively small openings 46 at a plurality of positions in the film 44. By doing this, the occurrence of holes and voids in the film 44 can be prevented, and a loss of adhesion force can be avoided. When forming the opening 46 in the film 44, if the film 44 is formed thinly, it is easy for the adhesive 30 to enter the opening 46, and thus for air to escape, and this is therefore preferable.

[0047]

For the method of manufacture of this embodiment of the semiconductor device, the method described in the first embodiment can be applied. If a metal foil or conductive foil is etched to form the leads 12 and film 44, the opening 46 can be formed at the same time.

[0048]

Third Embodiment

Fig. 5 shows a third embodiment of the semiconductor device to which the

present invention is applied. This embodiment of the semiconductor device comprises a substrate 50, and the semiconductor element 20 and adhesive 30 described in the first embodiment. The substrate 50 is the substrate 10 described in the first embodiment, in which through holes 52 are formed, and leads 54 are formed on the surface opposite to that of the leads 12, and since otherwise the construction is the same as that of the substrate 10, description is omitted here.

[0049]

The through holes 52 are formed between some of the plurality of leads 12 formed on one surface of the substrate 50 and some of the plurality of leads 54 formed on the other surface of the substrate 50. Each of the through holes 52 is provided with a conductive material by plating of gold or the like or by soldering, so that the leads 12 and 54 on both side of the substrate 50 are electrically connected. On the leads 54 formed on the other surface of the substrate 50 is formed external electrodes 56 as solder balls or the like. Otherwise for the construction and the method of manufacture may be applied the same construction and method of manufacture as in the first embodiment.

[0050]

Fig. 6 shows a circuit board 1000 on which is mounted the semiconductor device 1100 according to an embodiment of the present invention. For the circuit board an organic substrate such as for example a glass epoxy substrate is commonly used. On the circuit board, is formed an interconnect pattern of for example copper formed into a desired circuit, and by the mechanical connection of this interconnect pattern to the external electrodes of the semiconductor device, the electrical conduction is achieved.

[0051]

As an example of an electronic instrument to which the present invention is applied, Fig. 7 shows the substrate 10 on which the semiconductor element 20 is mounted, with a liquid crystal panel 60 fitted. The semiconductor element 20 is the

driver for the liquid crystal panel 60.

[0052]

It should be noted that the above-described "semiconductor element" of the present invention may be replaced by "electronic element," and an electronic component can be manufactured by mounting an electronic element (whether an active element or a passive element) on the substrate in the same way as a semiconductor element. As electronic components manufactured using such an electronic element may be cited, for example, resistors, capacitors, coils, oscillators, filters, temperature sensors, thermistors, varistors, variable resistors, and fuses.

[0053]

[Brief Description of the Drawings]

[Fig. 1] Fig.1 is a first embodiment of the semiconductor device according to the present invention.

[Fig. 2] Fig. 2 is a substrate of the first embodiment of the semiconductor device according to the present invention.

[Fig. 3] Fig. 3 is a second embodiment of the semiconductor device according to the present invention.

[Fig. 4] Fig. 4 is a substrate of the second embodiment of the semiconductor device according to the present invention.

[Fig. 5] Fig. 5 is a third embodiment of the semiconductor device according to the present invention.

[Fig. 6] Fig. 6 is a circuit board on which is mounted a semiconductor device according to the present invention.

[Fig. 7] Fig. 7 is an electronic instrument equipped with a semiconductor device manufactured by a method according to the present invention.

[Explanation of Reference Numerals]

	10	Substrate
	12	Lead
	14	Film
	20	Semiconductor element
5	22	Electrode
	30	Adhesive

[Title of Document] ABSTRACT

[Abstract]

[Object] To provide a semiconductor device and method of manufacture thereof, a circuit board, and an electronic instrument, such that holes and voids rarely occur in the surface of the substrate.

[Arrangement] There are provided a step of providing an adhesive 30 between a surface of a semiconductor element 20 having electrodes 22, on which the electrodes 22 are formed and a surface of a substrate 10 having leads 12, on which the leads 12 are formed; a step of positioning at least one of the electrodes 22 and at least one of the leads 12 to oppose each other; and a step of applying pressure in the direction of making the gap between the semiconductor element 20 and substrate 10 narrower, and on the substrate 10, in a region opposing the surface of the semiconductor element 20 and avoiding the leads 12, a film is formed with lower adhesion with the adhesive 30 than the substrate 10.

[Selected Figure] Fig. 1